G. M. SAPERS
USDA Eastern Utilization R&D Div., ARS, Philadelphia, Pa. 19118

FLAVOR QUALITY IN EXPLOSION PUFFED DEHYDRATED POTATO. 2. Flavor Contribution of 2-Methylpropanal, 2-Methylbutanal and 3-Methylbutanal

SUMMARY—Headspace vapor components previously associated with the intensity of an off-flavor in explosion puffed dehydrated potatoes were added to potatoes lacking the off-flavor to determine the flavor contribution of these compounds. 2-Methylpropanal produced a characteristic wet fur flavor note while 2- and 3-methylbutanal modified this flavor and contributed burnt flavor notes. While these flavor notes resembled some elements of the puffing off-flavor, the total off-flavor at its normal intensity could not be simulated by combinations of these compounds in potato at realistic concentrations. Acetone, which is also present in the headspace vapor of explosion puffed dehydrated potatoes, was found as a major headspace component of fresh boiled potatoes. This compound and smaller amounts of 2- and 3-methylbutanal were produced in overcooked fresh potatoes which lacked the puffing off-flavor.

INTRODUCTION

PREVIOUS STUDIES of an off-flavor produced by puffing in explosion puffed dehydrated potatoes showed that the intensity of this flavor was associated with the heights of peaks corresponding to 2-methylpropanal (2 MP) plus acetone and 2-methylbutanal (2 MB) plus 3-methylbutanal (3 MB) obtained by GLC analysis of potato headspace vapor (Sapers et al., 1970). The significance of this association with regard to the flavor contribution of these compounds is examined in the research reported herein.

EXPERIMENTAL

Addition of aldehydes to dehydrated potatoes

The contribution of 2 MP, 2 MB and 3 MB to the flavor of dehydrated potatoes was determined by adding these compounds (City Chemical Corporation) at realistic concentrations, individually and in combination, to conventionally dehydrated potatoes after reconstitution and by comparing their flavor with that of explosion puffed dehydrated potatoes. Both dehydrated products were prepared from the same lot of Idaho Russet potatoes using the same process except for the omission of the puffing step with the conventional potato. The explosion puffed and conventional products were reconstituted in boiling water (30g/500 ml) for 5 min and 20 min, respectively. After reconstitution, the puffed sample was found to have a moderate level of the "puffing" off-flavor while the conventional sample had a normal flavor. Immediately after reconstitution, aliquots of freshly prepared aqueous aldehyde solutions were added to samples of conventionally dehydrated potatoes to produce concentrations comparable to those calculated from headspace vapor analyses of potatoes having the off-flavor. Standard curves of peak height vs aldehyde concentration, described by Sapers et al. (1970), were used for this purpose. GLC analyses showed that the aldehydes contained only trace quantities of impurities.

The aroma and flavor of samples to which aldehydes had been added were compared with that of a conventionally dried control and the corresponding puffed product, all samples being examined hot by a three-member expert panel.

Aldehyde concentrations in fresh and dehydrated potatoes

Samples of fresh and dehydrated Idaho Russet potatoes were subjected to different thermal treatments and were then analyzed for 2 MP + acetone and 2 MB + 3 MB by the headspace vapor procedure described previously (Sapers et al., 1970) to determine the relationship between these compounds and potato flavor.

Raw potato dice (65g) were added to 250 ml of preboiled water in the headspace vapor flask and were "cooked" under the same conditions as those used for generating headspace vapor. A vapor sample was taken after 25 min and analyzed by the standard GLC procedure modified by the omission of the inlet splitter and by the use of a lower attenuation (× 5).

Raw potatoes were wrapped in aluminum foil, baked for 60 min at 225° in an oven, diced, added to preboiled H_2O (65g/250 ml) in the headspace vapor flask, heated for 25 min and analyzed as described above.

Raw potato dice (65g) were pressure cooked for 45 min at 15 psi, placed in 250 ml preboiled H_2O in the headspace vapor flask, heated for 25 min and analyzed as described above.

A sample of explosion puffed dehydrated potato prepared from the same raw material as used elsewhere in the experiment was also analyzed by the headspace vapor procedure.

The aroma of each sample was noted after the completion of the headspace vapor analysis.

Mass spectral analyses of fresh boiled potato headspace vapor

A mass spectral analysis of the 2 MP + acetone component of fresh cooked potato headspace was obtained using the same GLC mass spectrometer system described previously (Sapers et al., 1970). The sample was prepared by adding 65g of diced raw Idaho Russet potatoes to 250 ml of boiling saturated Na_2SO_4 solution in a 500 ml Erlenmeyer flask, equilibrating the mixture in a boiling water bath for 80 min and then withdrawing 2 ml of headspace vapor for analysis.

Resolution of aldehyde peaks

The headspace vapor analytical procedure was modified by the substitution of a capillary column for the 1/8" Carbowax 20M packed column to improve the resolution of the aldehyde peaks and to locate additional peaks which might be associated with the "puffing" off-flavor.

The capillary column (Perkin Elmer No. 2) was stainless steel, 50 ft × .02 in., coated with

Table 1—Flavor contribution of 2-methylpropanal (2 MP), 2-methylbutanal (2 MB) and 3-methylbutanal (3 MB) to dehydrated potatoes.

Sample	Added Aldehyde Conc. (ppm) 2 MP	2 MB	3 MB	Aroma	Flavor
Puffed	0	0	0	Typical off	Typical off
Conventional	0	0	0	Normal	Normal
Conventional	0.16	0	0	V. Sl. abnormal	Sl. wet fur
Conventional	0.32	0	0	Sl. abnormal	Wet fur
Conventional	0	0.16	0	V. Sl. burnt	Baked potato
Conventional	0	0.32	0	Sl. burnt	Aldehyde
Conventional	0	0	0.16	Sl. burnt	Sl. burnt
Conventional	0	0	0.32	Weak off	Weak off
Conventional	0.16	0.16	0	Weak raw peas	Sl. wet fur
Conventional	0.16	0.32	0	Wet fur	Wet fur
Conventional	0.32	0.16	0	Wet fur	Strong wet fur
Conventional	0.32	0.32	0	Raw peas	Burnt – weak off
Conventional	0.16	0	0.16	Wet fur	Wet fur
Conventional	0.16	0	0.32	Raw peas	Burnt
Conventional	0.32	0	0.16	Aldehyde	Wet fur
Conventional	0.32	0	0.32	Strong raw peas	Wet fur
Conventional	0	0.16	0.16	Raw peas	Burnt – aldehyde
Conventional	0.16	0.16	0.16	Raw peas > wet fur	Wet fur
Conventional	0.32	0.16	0.16	Raw peas > wet fur	Weak off

Table 2—Headspace vapor composition of fresh and dehydrated potatoes.

Sample	Peak height (cm)[a] 2 MP + acetone	2 MB + 3 MB	Aroma
Explosion puffed dehydrated	11.40	11.70	Typical off
Conventional dehydrated	4.35	1.40	Normal
Fresh boiled potato (25 min at 98°)	9.65	0.60	Sl. raw boiled potato
Fresh baked potato (60 min at 225°)	12.00	1.55	Baked potato
Fresh pressure cooked potato (45 min at 15 psi)	25.00	7.80	Over-baked potato

[a]No splitter; headspace vapor analyzed after 25 min equilibration; attenuation 5×.

Table 3—Partial resolution of potato headspace vapor components with capillary column.[a]

Sample	Peak height (cm)[b] 2 MP	Acetone	2 MB	3 MB	Aroma
Explosion puffed	5.35	3.05	3.10	3.10	Off
Explosion puffed	2.90	2.30	1.80	1.30	Sl. off
Conventional dehydrated	0.85	2.30	0.60	0.45	Normal
Fresh "boiled" (25 min at 98°)	Trace	8.75	0.60	0.50	Boiled
Fresh pressure cooked (45 min at 15 psi)	Trace	11.60	2.50	2.10	Over-baked

[a]Headspace vapor sampled after 25 min; attenuation 5×.
[b]Peak heights measured directly from partially resolved peaks.

Carbowax 1540. An inlet splitter (Perkin Elmer Split Needle Assembly N 72822) was used to give a split ratio of approximately 3 and a helium flow rate through the column of 12 ml/min. A column temperature of 30° was used. Other operating conditions were the same as those described previously (Sapers et al., 1970).

Headspace vapor analyses were performed on explosion puffed, conventionally dehydrated and fresh cooked potatoes using the capillary column and previously described techniques for sample preparation.

Headspace vapor analyses were also performed on aqueous solutions of acetone, 2 MP, 2 MB and 3 MB and on fresh boiled and explosion puffed potatoes to which these compounds had been added.

RESULTS & DISCUSSION

Contribution of aldehydes to the flavor of dehydrated potatoes

The flavor contribution of 2 MP, 2 MB and 3 MB added to conventionally dehydrated potato after reconstitution is summarized in Table 1. The typical off-flavor found in explosion puffed dehydrated potatoes can be resolved into three major flavor notes: the first a scorched or burnt note resembling the flavor developed by non-enzymatic browning during storage of a dry food; the second resembling wet fur or laundry; and the third a toasted flavor similar to that of nuts or dry cereal products and suggestive of pyrazines.

The addition of 2 MP, alone and in combination with the aldehydes, produced the wet fur note of the "puffing" off-flavor. This flavor did not occur when 2 MP was omitted from the mixture. The presence of the other aldehydes with 2 MP modified the wet fur note, in some cases producing an aroma reminiscent of raw peas and burnt flavors, the latter being similar to a weak "puffing" off-flavor at the highest level of 2 MP + 3 MB.

The addition of 2 MB and 3 MB individually produced burnt flavors which in the case of 3 MB at the higher concentration resembled the "puffing" off-flavor at a very low level. 2 MB and 3 MB added together at the lower concentration (this combination using higher concentrations would not be representative of potato headspace vapor composition) produced a raw pea aroma and a burnt flavor similar in some respects to the flavor of the aldehyde solutions.

The most realistic "puffing" off-flavor was produced by the three component mixture, 2 MP being at the higher concentration and 2 MB and 3 MB being at the lower concentration. As with all other samples containing added aldehydes, the off-flavor intensity of this sample was substantially lower than that of the explosion puffed potato. This was true, even though the headspace vapor aldehyde peak heights corresponding to the three component mixture would resemble chromatograms obtained with explosion puffed potatoes having high levels of the off-flavor.

It is apparent, therefore, that important elements of the "puffing" off-flavor (i.e., the toasted flavor note) are due to the presence of compounds other than 2 MP, 2 MB and 3 MB even though these compounds contribute some wet fur and burnt notes to potato.

Headspace vapor composition of fresh and dehydrated potatoes

Headspace vapor analyses were performed on fresh cooked and dehydrated potatoes using the packed Carbowax 20M column which was not capable of resolving 2-methylpropanal and acetone or 2-methylbutanal and 3-methylbutanal. Peak heights for these headspace vapor components are summarized in Table 2.

Fresh boiled and baked potatoes having typical cooked potato aromas were found to have a 2 MP + acetone peak comparable in height to explosion puffed potato having the off-flavor. Mass spectral analysis of the headspace vapor above boiled potato showed this peak to be acetone; previously reported analyses of explosion puffed potato showed the corresponding peak to be a mixture of 2 MP and acetone (Sapers et al., 1970). Consequently, 2 MP rather than acetone is associated with the off-flavor.

Fresh potato, pressure cooked at 15 psi until a brown color and an over-baked flavor were produced, developed a significantly higher 2 MP + acetone peak and a 2 MB + 3 MB peak comparable to that obtained with the puffed sample.

These relationships were further clarified by headspace vapor analyses of fresh

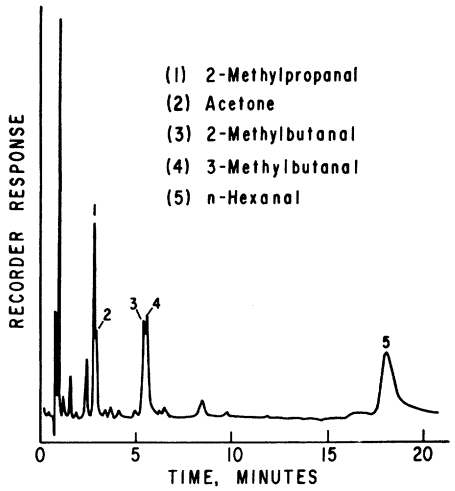

Fig. 1—Headspace vapor analysis of explosion puffed dehydrated potato using Carbowax 1540 capillary column.

cooked and dehydrated potatoes using a Carbowax 1540 capillary column which was capable of partially resolving the 2 MP + acetone and 2 MB + 3 MB peaks (Fig. 1).

Peak heights obtained from these analyses (Table 3) were subject to error because of the mutual contribution of the partially resolved components to each peak and could not be used for quantitative determinations; however, large differences between samples could be established without difficulty.

It can be seen from Table 3 that 2 MP was associated with the off-flavor in dehydrated potatoes and was present only in trace quantities in the headspace vapor above fresh cooked potatoes. The acetone peak was found to be smaller than the 2 MP peak and was not associated with the off-flavor in dehydrated potatoes. Acetone was a major headspace vapor component of fresh boiled potatoes and increased with over cooking.

The 2 MB and 3 MB peaks were approximately equal in height in explosion puffed potatoes having the off-flavor and were both associated with the intensity of the off-flavor. These components were present at low levels in the headspace vapor of boiled potato and were increased to levels comparable to those from puffed potatoes by pressure cooking.

These results show that the association between headspace vapor components and the puffing off-flavor in dehydrated potatoes is meaningful but subject to several limitations. Unless separations are carried out with columns capable of resolving 2 MP and acetone, some confusion may result from the coincidence of these components, the former compound being associated with elements of the off-flavor and the latter component being a normal constituent of fresh cooked potatoes (Self and Swain, 1963). Furthermore, the association should not imply a cause and effect relationship between the off-flavor and the headspace vapor aldehydes. Other compounds, not detected by this method, certainly contribute to the off-flavor. No conclusions can be drawn regarding the cause and means of elimination of the off-flavor until these compounds are identified. Research along these lines is continuing.

REFERENCES

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